HelioAnalytics: A Small Field with Big Data Science

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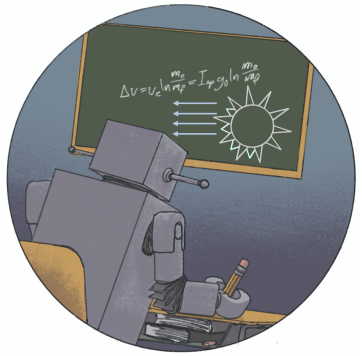
and the CfHA Team

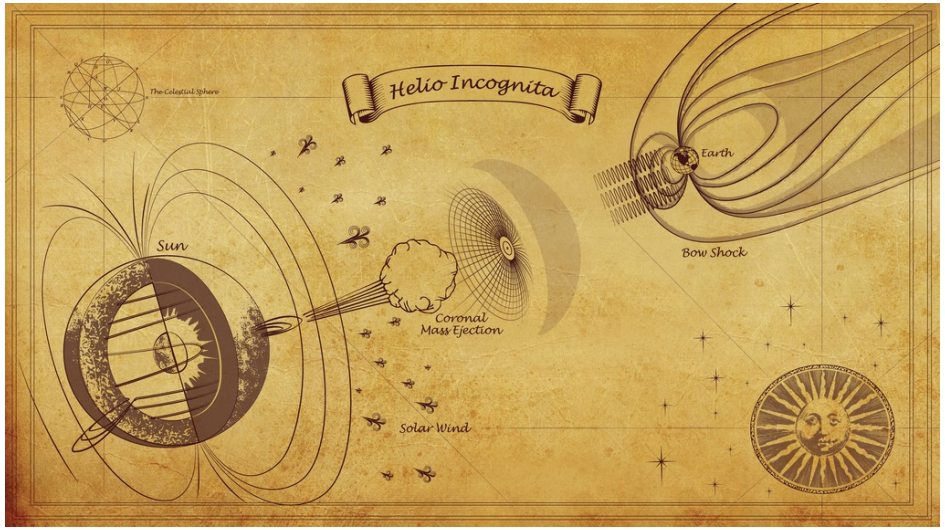
Image art: Mary-Pat Hrybyk



What is HelioAnalytics?

HelioAnalytics is the cross-disciplinary convergence of communities of physicists, statisticians, and computer scientists.

It is intended to foster research into advanced methodologies for heliophysical research, and to promulgate such methods into the broader community.



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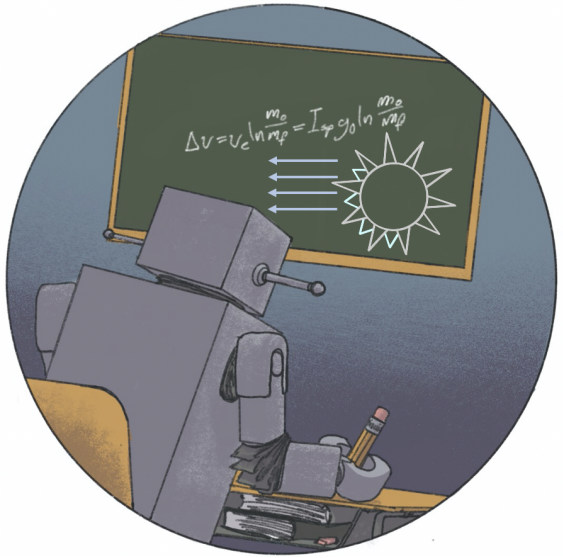
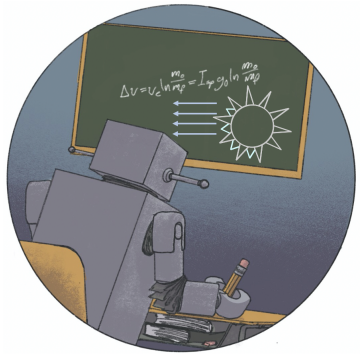


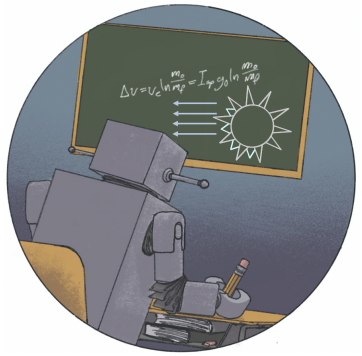


What is HelioAnalytics?

Heliophysics is a small field with Big Data Science. HelioAnalytics focuses on problems that we can attack with modern methods that we cannot address otherwise.

Center for HelioAnalytics (CfHA) Objectives:

- Establish a community of practice among Heliophysics data scientists
- Support efforts to harness data science to drive Heliophysics scientific discovery
- Build sustainable connections to expand the potential of key Heliophysics research and missions
- Support, promote, and implement responsible and ethical AI at all practicable levels



Why HelioAnalytics?

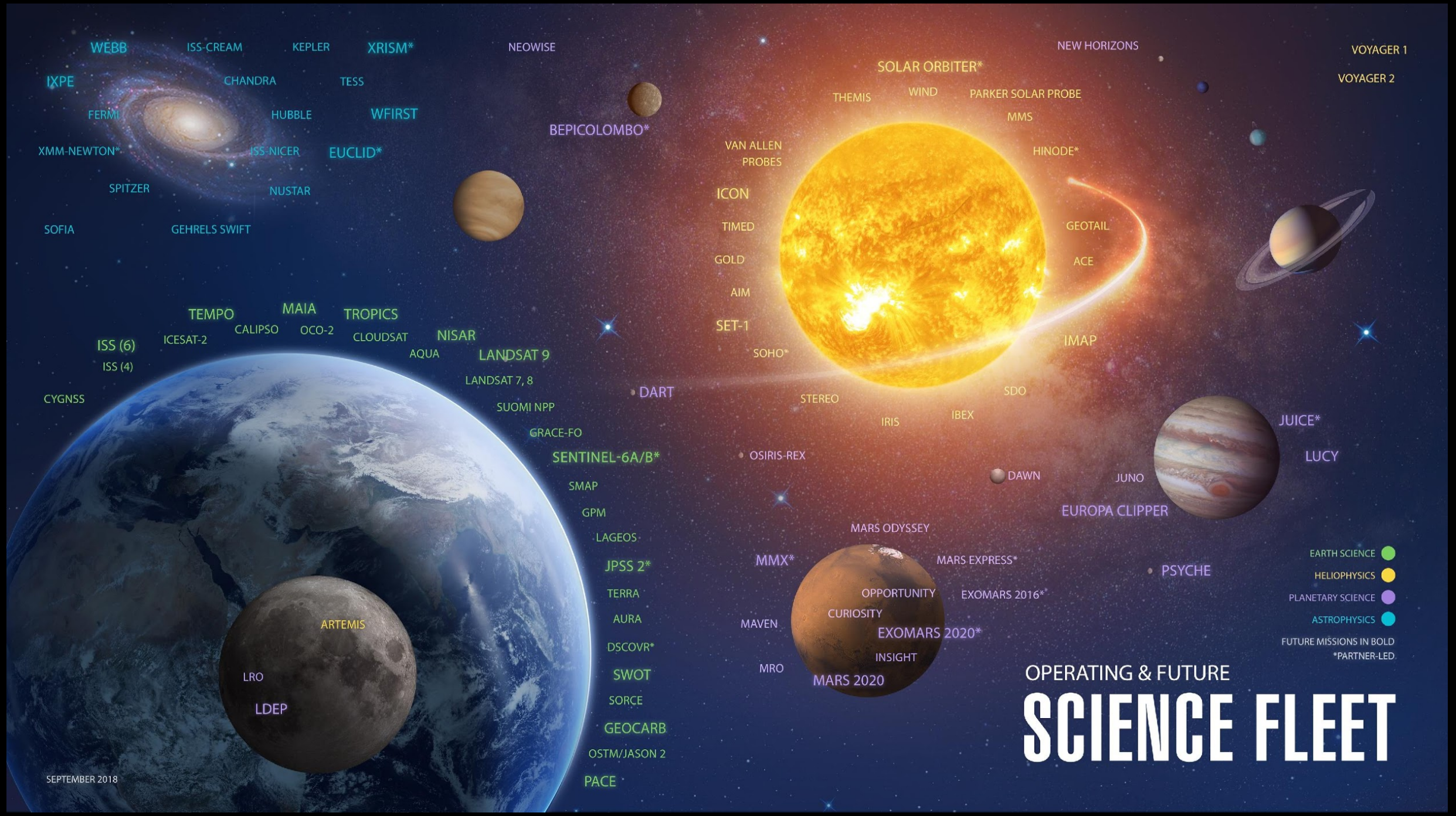
Why do we need a data science effort devoted specifically to Heliophysics?

Heliophysics is small relative to the other science divisions. However, the range of problems, domains and types of data inside heliophysics presents many challenges. The heterogeneity makes a coordinated data science effort critical.

A focused data science effort leads to a more nuanced and comprehensive understanding of these myriad processes governing Heliophysics.

Moreover, Heliophysics has cross-cutting cross-disciplinary relationships that easily connect to, and are applied to, all the other NASA science areas.

We hope this presentation will inspire you to think of other cross-cutting data science opportunities!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ISS-NICER
EUCLID*
SPITZER
NUSTAR
SOFIA
GEHRELS SWIFT
SOLAR ORBITER*
NEW HORIZONS
VOYAGER 1
VOYAGER 2
THEMIS
WIND
PARKER SOLAR PROBE
MMS
VAN ALLEN PROBES
HINODE*
ICON
TIMED
GOLD
AIM
SET-1
GEOTAIL
ACE
IMAP
SOHO*
TEMPO
MAIA
TROPICS
CALIPSO
OCO-2
CLOUDSAT
NISAR
ISS (6)
ICESAT-2
AQUA
LANDSAT 9
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CYGNSS
DART
SUOMI NPP
STEREO
SDO
IRIS
IBEX
JUICE*
GRACE-FO
SENTINEL-6A/B*
OSIRIS-REX
LUCY
DAWN
JUNO
SMAP
EUROPA CLIPPER
GPM
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JPSS 2*
MMX*
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OSTM/JASON 2
PACE
SEPTEMBER 2018
EARTH SCIENCE
HELIOPHYSICS
PLANETARY SCIENCE
ASTROPHYSICS
FUTURE MISSIONS IN BOLD
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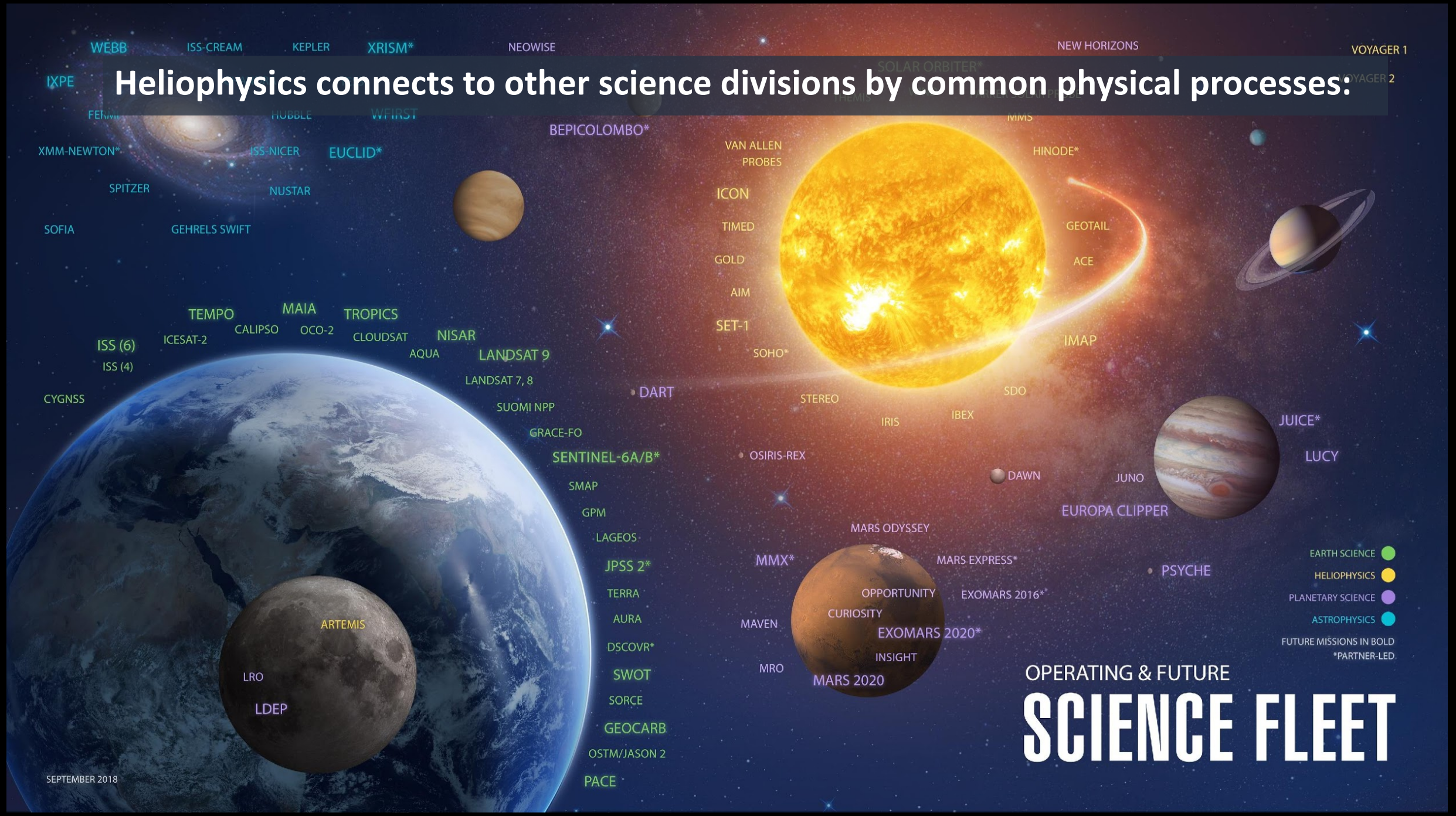
OPERATING & FUTURE
SCIENCE FLEET

Heliophysics connects to other science divisions by common physical processes:



Heliophysics connects to other science divisions by common physical processes:

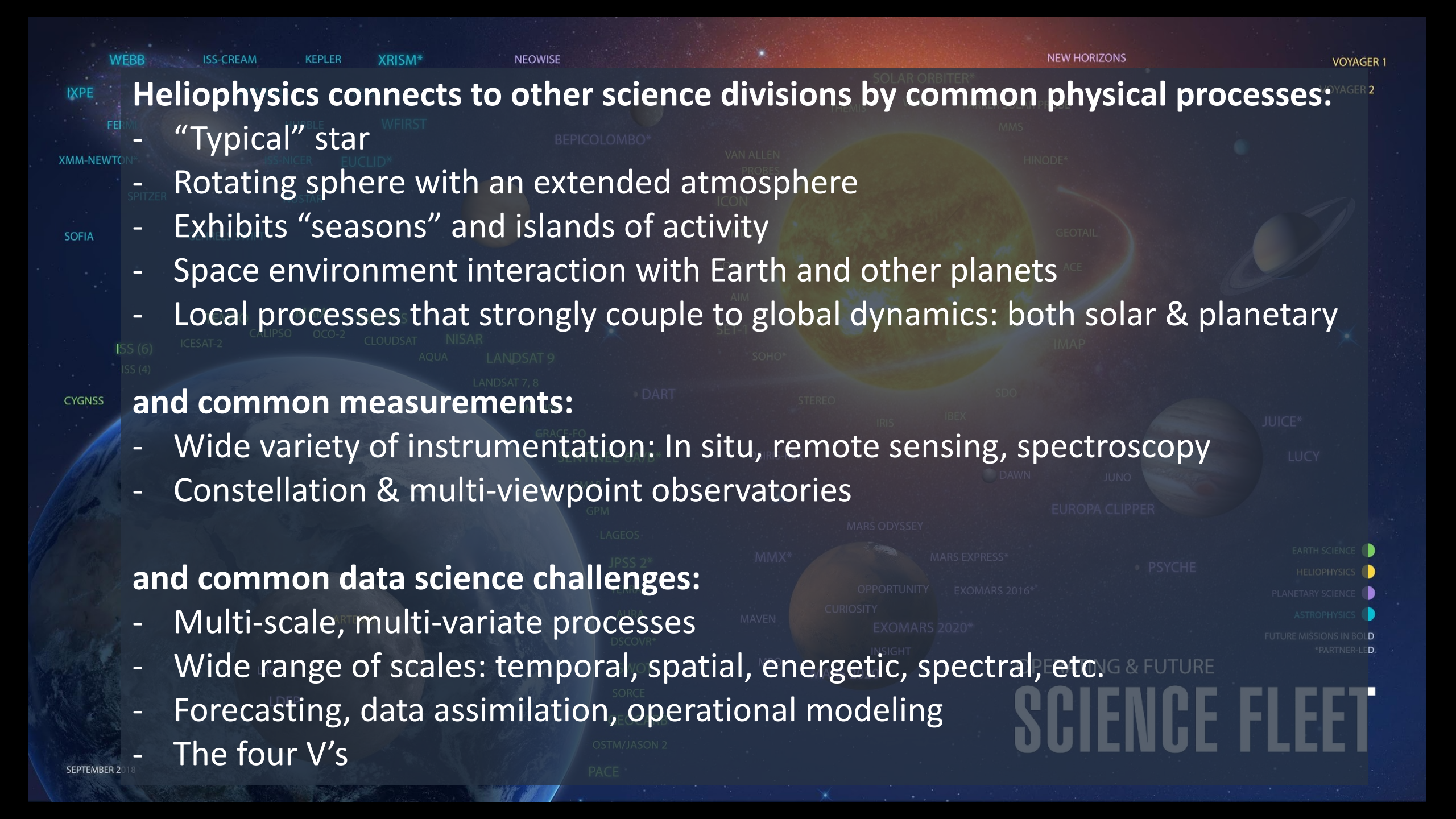
- "Typical" star
- Rotating sphere with an extended atmosphere
- Exhibits "seasons" and islands of activity
- Space environment interaction with Earth and other planets
- Local processes that strongly couple to global dynamics: both solar & planetary

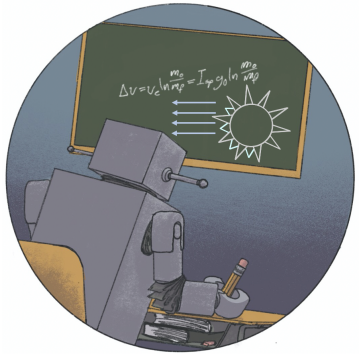
and common measurements:

- Wide variety of instrumentation: In situ, remote sensing, spectroscopy
- Constellation & multi-viewpoint observatories

and common data science challenges:

- Multi-scale, multi-variate processes
- Wide range of scales: temporal, spatial, energetic, spectral, etc.
- Forecasting, data assimilation, operational modeling
- The four V's





Cross-cutting Opportunities

The Center for HelioAnalytics organizes projects into four “Pillars of Impact.” It realigns activities not according to method, but according to community impact and value.

The Pillars of Impact allow clear connections to data science activities with our partners throughout NASA and the scientific community.

CfHA Pillars of Impact

Mission-Enabling Development

Activities that expand the capabilities and/or reduce the cost of science missions

- Science Autonomy: intelligent onboard decisions
- Data Economy/Data Budgeting for telemetry optimization: compression vs. segmentation
- Data Enhancement and Adaptive Strategies

Science Data Discovery

Activities that derive greater insight and value from data and models; deploying data science across databases

- Identifying physical & statistical relationships in Heliophysics datasets
- Using data to gain a richer understanding from physical models
- Predicting extreme events and/or anomalies
- Detection of features, identifying phenomena, characterizing events

Strategic Partnerships & Resources

Activities that focus on capturing knowledge and build data science capability throughout the community

- Knowledge sharing & capture
- Identifying new creative partnerships
- Collections and Repositories: open-source code, AI-ready data, guides and learning tools
- Workshop, committee, and hackathon coordination point
- The Helionauts community problem-solving resource

Advanced Capabilities & Method Enhancement

Targeted adaptation and development of methods for a specific problem or asset; technology bridging activities

- Physics-Informed Learning
- AI/ML Simulation and Physical Model Emulators
- Deep Learning for Data Assimilation
- Platform optimization and HPC (cloud, GPU, quantum computing)
- Data Pipelining Enhancements

Ethical and Responsible AI: A pillar, and a foundation

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Responsible and Ethical AI

The practice of Ethical AI includes implementing Trustworthy AI practices, monitoring for bias in the establishment and interaction of teams, and understanding the full societal implications (benefits or not) of our results.

- Encourage ethical interpretation and use of our data, code, and results
- Compile and monitor for social bias issues, and develop possible mitigation strategies
- Engage diverse voices in both data science and equity leadership to address bias issues
- Feature talks and sessions concerning Responsible AI at data science conferences we organize

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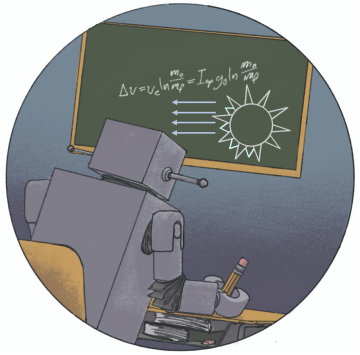
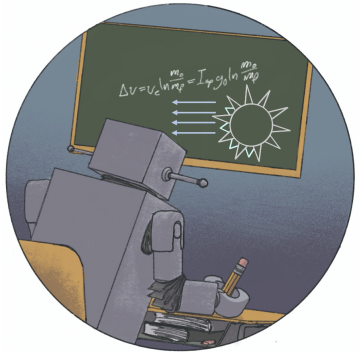


Why HelioAnalytics?

- Well-connected to our constituency (the Heliophysics research community)
- Team members are well integrated: Strong roots support strong branches
- Team formulation prioritizes partnerships and connections to other data science groups
- **Our ability to connect means that we can benefit from other areas, and *vice versa.***

We are eager to extend these connections.

Come to our Networking Reception!!



Heliophysics presentations

Talk 28 Ryan McGranaghan: New Modes of Collaboration Across NASA Via Data Science: Progress Through a Space Weather Use Case

Poster 37 Kendall Johnson: Solar Flare Prediction using Convolutional Neural Nets

Poster 43 Brad Neuberg & Valentina Salvatelli: Auto-Calibration and High-Fidelity Virtual Observations of Remote Sensing Solar Telescopes with Deep Learning

Poster 44 Daniel da Silva: Compressed Image Artifact Removal: Improving Instrument Data Quality After Lossy Compression

Poster 45 James Parr: Best Practices in Sharing Enhanced Data Products and Machine Learning Algorithms: Learnings from NASA Frontier Development Lab (and Talk 29)

Poster 53 Michael Coughlan: Using an LSTM and Classification Methods to Determine Risk of dB/dt Threshold Crossings as Proxy for Geomagnetically Induced Currents

Poster 56 Paul Wright: Super-resolution of MDI Solar Magnetograms: Performance Metrics and Error Estimation

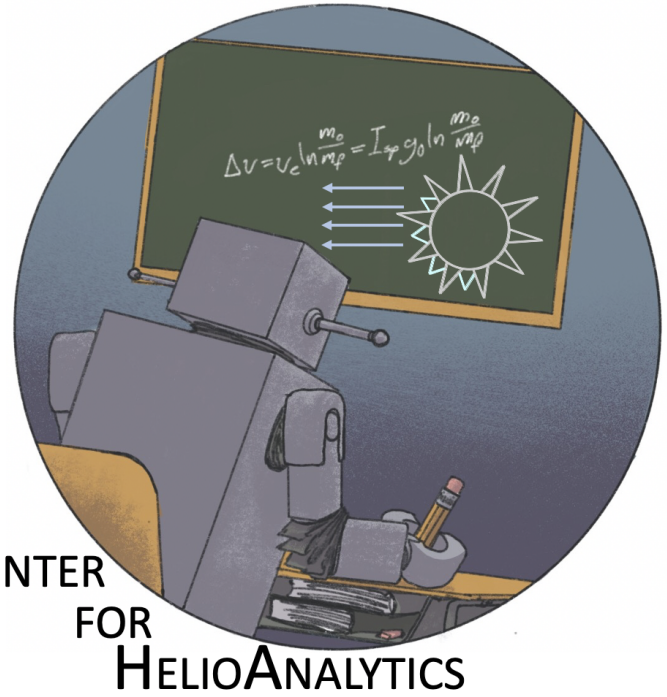
Poster 57 Amy Keesee: Comparison of Time Series Techniques to Model Connections Between Solar Wind Input and Geomagnetically Induced Currents

Poster 58 Michael Kirk: Developing Deep Learning for Solar Feature Recognition in Satellite Images

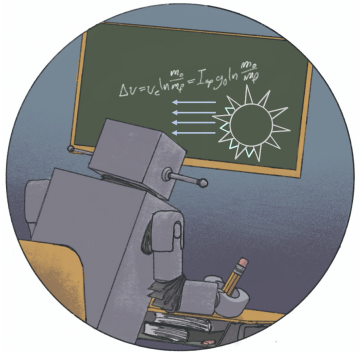
Poster 59 Kara Lamb: Correlation of Auroral Dynamics and GNSS Scintillation with an Autoencoder

Thank you!!


HELIOPHYSICS
NASA


CENTER
FOR
HELIOANALYTICS


NASA Goddard Space Flight Center
AI CENTER OF EXCELLENCE



Frontiers in HelioAnalytics and Space Missions

ML/AI capabilities are allowing us to aim higher, think bigger

- ML is removing some of the traditional limitations imposed on space missions.
- Robustness: gap fillers, reconstruction, signal variations
- More strategic data transmission choices: downscaling methods, onboard decisions, smart segmentation, sample selection
- AI-driven autonomy, anomaly detection, fault tolerance

Heliophysics is a well-connected community that is facing similar problems and challenges to the other NASA mission science divisions.

Strategic partnerships can be a stepping stone to future development.